THE MESSIER CATALOG

G. Iafrate, M. Ramella
INAF - Astronomical Observatory of Trieste

Information and contacts: **http://vo-for-education.oats.inaf.it** - **iafrate@oats.inaf.it**

Within this use case you meet representatives of the most interesting categories of celestial objects. From stellar clusters to galaxies. All objects are from the Messier catalog that includes some of the most viewed objects of the deep sky.

If used in the classroom this use case is basic and needs only modest supervision from teachers. Pupils will be able to explore the Messier catalog on their own and extend their exploration to the PR images of NASA's Hubble Space Telescope.

1 Introduction

Most objects visible in the sky by naked eye are stars, i.e. point sources. It is enough to watch the sky with an amateur instrument to discover that there are also luminous extended sources displaying quite a variety of different shapes.
In 1781, the French astronomer Charles Messier published the first catalog of 103 extended, or "*nebular*", objects. Seven more objects entered the catalog after its publication.
The 110 objects contained in the still popular Messier catalog are the most easily observable among all deep sky objects. In fact, if you live under a very dark sky, you can see some of them even by naked eye.
Messier objects are a mixed population that includes galaxies, gas clouds (or *nebulae*) and star clusters.

Following this use case you will explore some of the most representative objects of the Messier catalog. You will retrieve and visualize them with Aladin and Stellarium, an application that will let you check where to look for objects visible from your location.

2 The Messier catalog

The Messier catalog has been the first astronomical catalog of celestial objects different from stars. It has been edited by the French astronomer Charles Messier, with the original name of *Catalogs del Nèbuleuses et des Amas d'Etoiles*, and published in 1774.
Messier was searching for comets, as many other astronomers of the same period. A comet appears, observed through a telescope, like a faint nebular object very similar to a galaxy, a nebula

or a star cluster. Messier filled out his catalog in order to be able to easily distinguish between a new comet and the other similar objects fixed in the sky.
The Messier catalog includes galaxies, nebulae, open and globular star clusters and supernova remnants.

3 Aladin

Aladin is an interactive sky atlas developed and maintained by the Centre de Donnèes astronomiques de Strasbourg (CDS) for the identification of astronomical sources through visual analysis of reference sky images. It is available for download here: https://aladin.u-strasbg.fr/java/Aladin9.0.jar.
Aladin allows the user to visualize digitized images of any part of the sky, to superimpose entries from the CDS astronomical catalogs and tables, and to interactively access related data and information from various data servers (like SIMBAD, NED, VizieR). In this usecase we use Aladin in the *undergraduate* mode: start Aladin and switch to the undergraduate mode from the menu:

edit -> user preferences -> profile -> undergraduate.

Restart Aladin in order to validate the new configuration.

4 Stellarium

Stellarium is a free software that transforms a home computer in a planetarium. It calculates the positions of Sun and Moon, planets and stars, and draws the sky how it would be seen from an observer anywhere on the Earth and at any epoch. Stellarium can also draw the constellations and simulate astronomical phenomena such as meteor showers and solar or lunar eclipses.
Stellarium may be used as an educational tool for kids of all ages, as an observational aid for amateur astronomers wishing to plan an observing night, or simply to explore the sky (it is fun!). Stellarium shows a realistic sky, very close to what you see with naked eye, binoculars or telescope. Stellarium gives astronomical data (coordinates, magnitude, distance, etc.) of most of the celestial objects visualized on the screen.
You can freely download Stellarium from our site http://vo-for-education.oats.inaf.it or from http://www.stellarium.org.

5 Supernova remnants

Start Aladin and enter “M1” in the location field. The Aladin main window shows the allsky map centred on the M1 supernova remnant, also called the “Crab Nebula”.
A supernova remnant is the material left by the huge explosion of a supernova. A supernova is a big, bright and hot star that collapses and then explodes expelling most of its matter having consumed its nuclear fuel at the end of its life-cycle.
M1 is one of the most famous supernova remnants and the first object catalogued by Messier (M stands for Messier and 1 is for object #1).

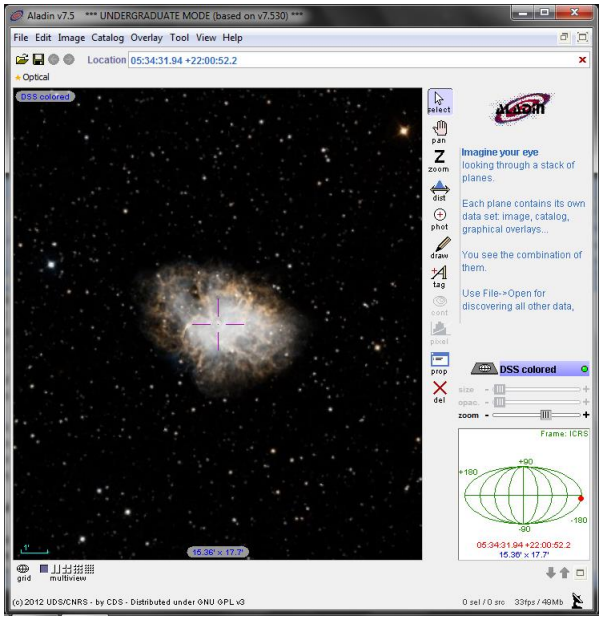

Fig. 1: Image of the Crab Nebula M1.

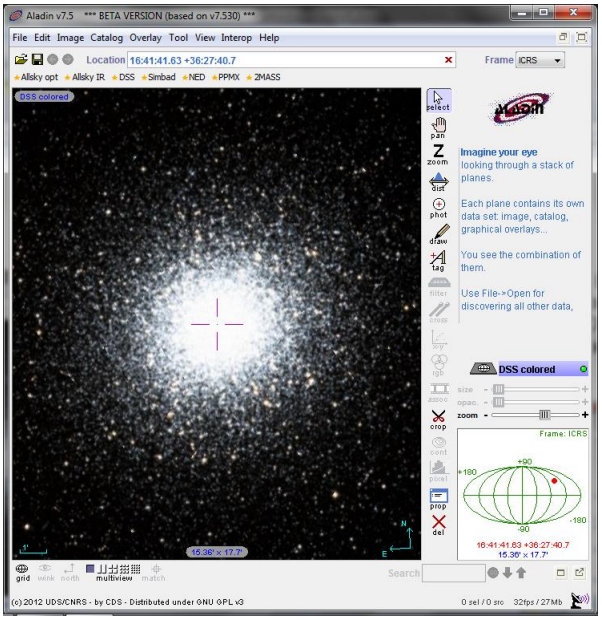

Fig. 2: Image of the globular cluster M13.

In visible light, the Crab Nebula consists of a oval-shaped mass of filaments that are the remnants of the progenitor star's outer gas layers (fig. 1). At the centre of the nebula lies the exotic neutron star called Crab Pulsar, a very small, extremely dense and fast rotating star made of tightly packed neutrons. The Crab Pulsar emits pulses of radiation from gamma rays to radio waves.
M1 is an historical supernova. It means that we have historical records of its appearance: in 1054DC both Chinese and Arab astronomers recorded the position of a new star, bright enough to be seen in the daytime. The Crab Nebula, observed by Messier exactly in the position recorded by Chinese astronomers, became the first astronomical object to be connected to a supernova explosion.

6 Globular clusters

Enter “M13” in the location field. The Aladin main window centres on the M13 globular cluster.

A globular star cluster is a system of hundreds of thousands of stars bound by gravity. Globular clusters are among the oldest objects in the Galaxy with ages in excess of 10 billion years, they orbit around the centre of our Galaxy as satellites forming a halo. Globular clusters have been used as probes to determine the structure of the Milky Way. We know more than 150 globular star clusters around the Milky Way, plus perhaps other to be discovered.
M13 is located in the constellation of Hercules, and is sometimes called the Great Globular Cluster in Hercules. It counts more than 300.000 stars and can be seen by naked eye under a dark sky. M13 was discovered by Edmund Halley in 1714 and then catalogued by Charles Messier.

7 Open clusters

Enter “M45” in the location field. The Aladin main window shows the allsky map centred on the Pleiades open cluster. Adjust the zoom level (reduce it) up to see a field of at least 1,5°x1,5°.

An open cluster contains up to a few thousands stars, all of them formed at the same time from the same molecular gas

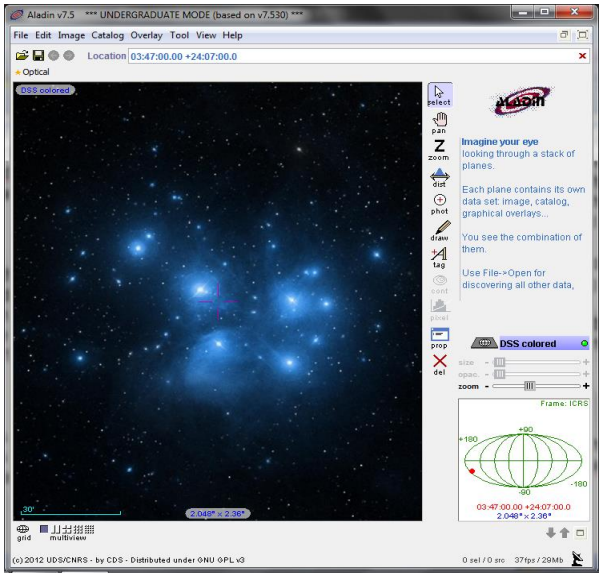

Fig. 3: Image of the Pleiades open cluster (M45).

and in fact open clusters lose rather easily their stars with time. Our Sun may have been once in an open cluster.
Open star clusters are relatively young objects, they are at most a few hundred million years old, and are composed by bright and hot stars.
Because the stars of an open star cluster have the same age and the same chemical composition, differences between them are only due to their mass. This fact makes open star clusters very important to understand stellar evolution.
In the Milky Way astronomers have observed more than 1000 open clusters. The best known and easiest to recognize is M45 (the Pleiades open cluster), which is easily observable by naked eye.
Ancient people used the Pleiades open cluster as a sight test: people able to distinguish the seventh dimmer star by naked eye have a good sight.

8 Planetary nebulae

Enter “M27” in the location field. The Aladin main window shows the allsky map centred on the M27 planetary nebula, known as the “Dumbbell Nebula”.
A planetary nebula is an astronomical object that appears, if observed at low magnification, nebular and disk shaped. Due to the aspect vaguely similar to that of a planet, the astronomer William Herschel introduced in 1785 the name “planetary nebula”.

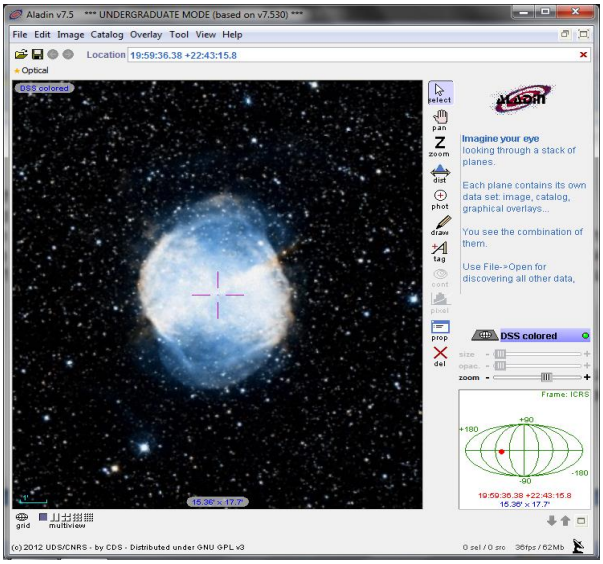

Fig. 4: Image of the planetary nebula M27.

Today we know that a planetary nebula is not related to planets. It originates from the last steps of the life-cycle of a star, when the star ejects its outer layers. While the nucleus contracts in a white dwarf, the ejected gas creates a gas cloud expanding around it at high velocity.
Also our Sun, according to the last theories on stellar evolution, will end its life-cycle creating a planetary nebula.
Planetary nebulae are not visible by naked eye, Charles Messier was the first to discover them.

9 Emission nebulae

Enter “M42” in the location field. The Aladin main window shows the allsky map centred on the Orion nebula. Adjust the zoom level until you have a field of view of about 2°x2°.
The Orion nebula is one of the brightest emission nebulae of the sky. It can be seen by naked eye south of the famous “Orion’s belt”, in the middle of the so-called “Orion’s sword”. The Orion nebula is a stellar nursery: inside it there are many very young stars and stars that are still forming.
An emission nebula is an interstellar cloud of gas illuminated by bright stars it embeds. The colour of the nebula depends on the density, temperature and ionization level of the gas that composes the nebula. Emission nebulae are composed by hydrogen, helium, oxygen and nitrogen. Emission nebulae often have dark spots where interstellar dust clouds absorb light.

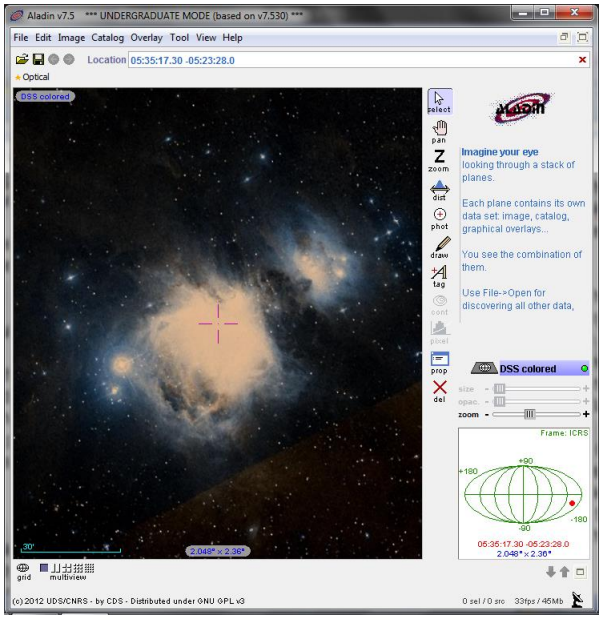

Fig. 5: Image of the Orion Nebula (M42).

10 Galaxies

A galaxy is a huge collection of stars, star clusters, nebulae, gas and dust bound by the gravity. Besides ordinary matter, galaxies are also composed by a large amount of “dark matter”, a kind of matter of yet unknown nature the we do not see directly but detect because of its effects on luminous matter. Galaxies are very large objects: their sizes are on the order of tens thousands or hundreds thousands light years and contain from few millions stars (dwarf galaxies) to hundred thousand billions stars (giant galaxies). All stars orbit around the centre of the galaxy.
Galaxies have been historically classified according to their apparent shape, or morphology. The main categories are spiral and elliptical galaxies.

* Spiral galaxies

Enter “M33” in the location field. The Aladin main window shows the allsky map centred on the so called “Triangulum” spiral galaxy.

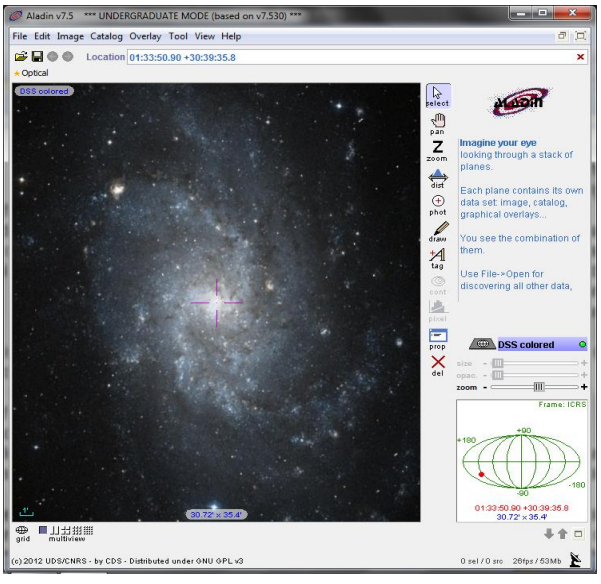

Fig. 6: Image of the spiral galaxy M33.

A spiral galaxy is characterized by a central bulge surrounded by a disk. The bulge contains mostly old stars and often, at its very centre, a massive black hole. The disk is made of young stars, open star clusters and gas clouds; it is flat, thin and rotating.
Spiral galaxies own their name to the bright spiral arms of the disk. These arms can be more or less visible, depending on the inclination of the disk: a spiral galaxy appears like a big spiral if we see it face-on, or like a disk if we see it side-on.
Our galaxy, the Milky Way, is a spiral galaxy very similar to the Andromeda galaxy (M31).
M33, the Triangulum galaxy, is the second brightest galaxy nearest to the Milky Way, beyond the Andromeda Galaxy. It is a beautiful face-on spiral, observable under dark skies with a binocular.
As an example of a spiral galaxy seen side-on enter “M65” in the location field. The Aladin main window shows the allsky map centred on the M65 side-on galaxy.

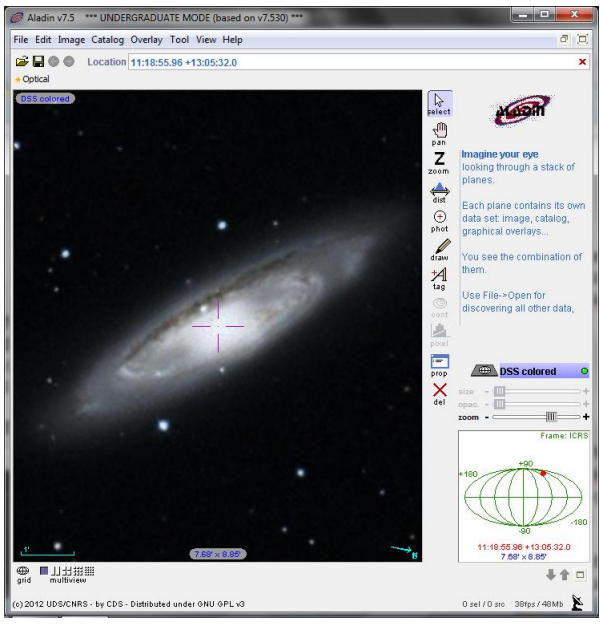

Fig. 7: Image of the spiral galaxy M65.

*** Elliptical galaxies**

Enter “M87” in the location field. The Aladin main window shows the allsky map centred on M87 elliptical galaxy.

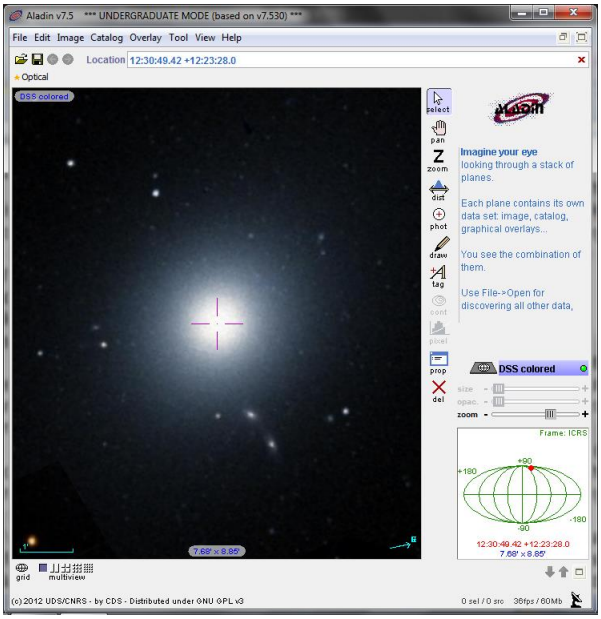

Fig. 8: Image of the elliptical galaxy M87.

Zoom on the galaxy in order to have a better view.
It is a galaxy with elliptical shape composed mainly by old stars and characterized by the lack of spiral arms. Elliptical galaxies can be from very small to giant: the two galaxies satellites of the Andromeda galaxy are dwarf galaxy, while M87 is a huge galaxy.
Star formation in elliptical galaxies has ended since a long time, now these galaxies shine thanks to stars that are getting old.
M87, also called Virgo A, is a giant elliptical galaxy in the Virgo constellation, discovered by Charles Messier in 1781. It dominates the Virgo cluster being one of the biggest galaxies known.

11 Hubble Space Telescope Images

For each one of the Messier objects in this use case, we can retrieve also Hubble Space Telescope images.

The Hubble Space Telescope, HST, is a telescope of 2,5 m diameter located in orbit around the Earth at about 560 km of altitude. It has been launched on April 24, 1990 by the Discovery Space Shuttle as a joint project between NASA and ESA.
HST produces very high quality images that are not degraded by the perturbations of our atmosphere plaguing ground telescopes.
Start Aladin and enter the name of the object in the “location field” in order to centre the Aladin view on that object.
Open the file menu and load the HST images:

file -> load astronomical image -> hubble press release images

a new windows opens, with the available images. Check one of them and press submit in order to load it in Aladin.
HST images are large, so they can take a long time to load: be patient!
It could occur that you receive the following message: “the query returns no data for this position”. It means that there are no available HST images for the object you entered.

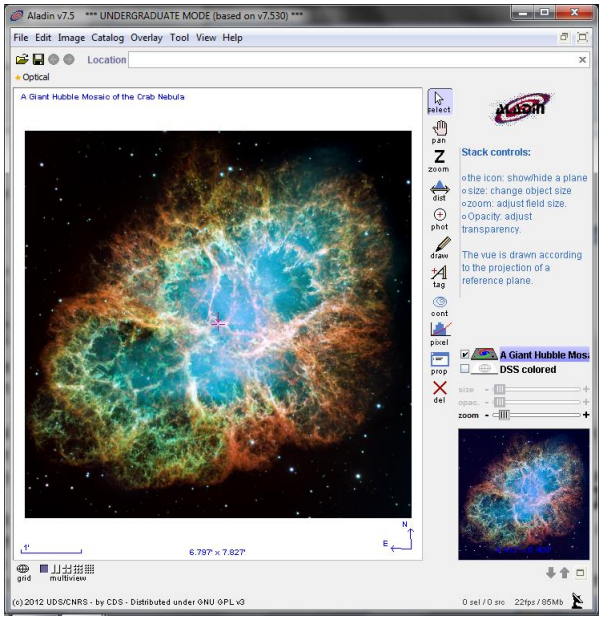

Fig. 9: A giant HST mosaic of the Crab Nebula.

12 Localize the objects in Stellarium

Open Stellarium, and set your location (location window -) and the time (date/time window -) of observations in the left menu.

Open the search window ( ) and insert the name of the object you want to look for.
Stellarium is now centered on the object: verify that the object is visible above the local horizon.
Use the mouse wheel in order to increase or decrease the field of view and pan it in order to watch a different part of the sky.
If the object is below the local horizon move forward in time in order to see when you will be able to observe it from your location. Some objects may be visible only during part of the year.